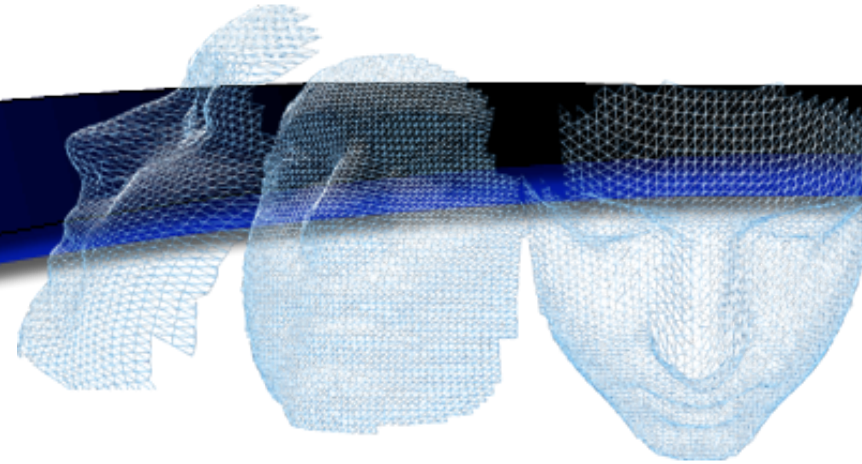


Quality of 3D Face Acquisition and it's Relation to the Performance

Artyom Yukhin,
CTO,
A4Vision Inc.

3D face is a reliable biometric Today…

…and not “a hope for future” !

Accuracy is of the same order as fingerprint & Iris

- FAR down to 10^{-6}…10^{-7} is achieved with “good“ op. FRRs
- oFRR(FAR=10^{-6}) = 2.5%
- oFRR(FAR=10^{-4}) < 1%
- oFRR(FAR=10^{-3}) < 1%

(FRR currently is mainly defined by poor ergonomics - to be significantly improved from usability and ergonomics)

Transaction time is low:

- Average Verification Time = 1sec
- Average Verification Transaction Time = 2-6 sec (*to be significantly improved from usability and ergonomics, depends on implementation, GUI)*

Stability for environmental changes and spoofing is high

Public Acceptance is good (the same as for traditional photo)

A4Vision
Applications for Vision

3D face is a reliable biometric Today… (continued)

Sensor: can be real time (25 samples/sec), of low cost and small sized

Capture procedure:

- contact less
- robust to ambient lightning conditions
- little cooperativeness required (positioning, moving, facial expressions)
- can be real-time with auto quality check

Data Format : INTEROPEABLE, 5kb, ANSI/ISO standardization in process

Applications: Physical access, e-passports, border control, logical access, CJIS (arrest booking, prisoners' release, investigation, forensic)

Operational Testing: , e-passports (Singapore, Russia), Airports (UK, France, USA), Commercial (banks, etc)

A4Vision
Applications for Vision

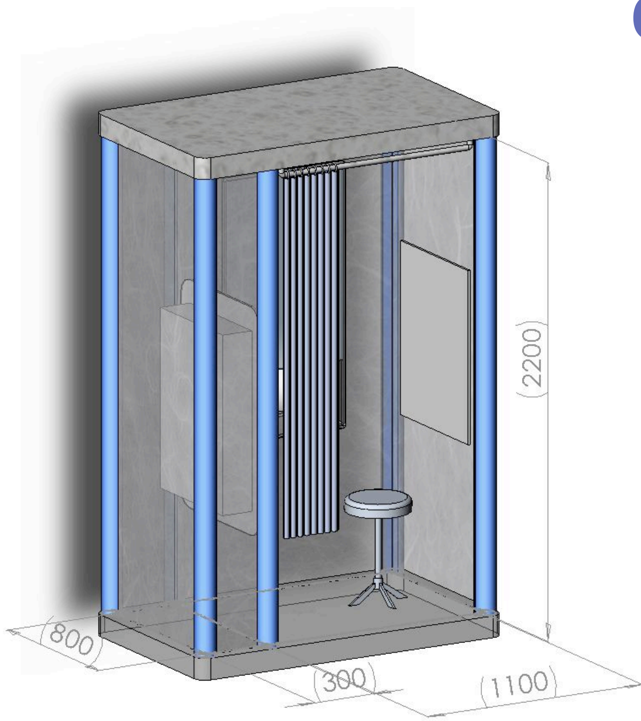
Applications: Physical Access Control

A4Vision FaceReader

NPO-Inform Tourniquet powered by A4Vision 3D Face technology

A4Vision
Applications for Vision

Applications: e-passports and border control



Russian National

e-passport program includes 2D + 3D biometrics.

Pilot region - Kaliningrad. 6-10 thousand people involved.

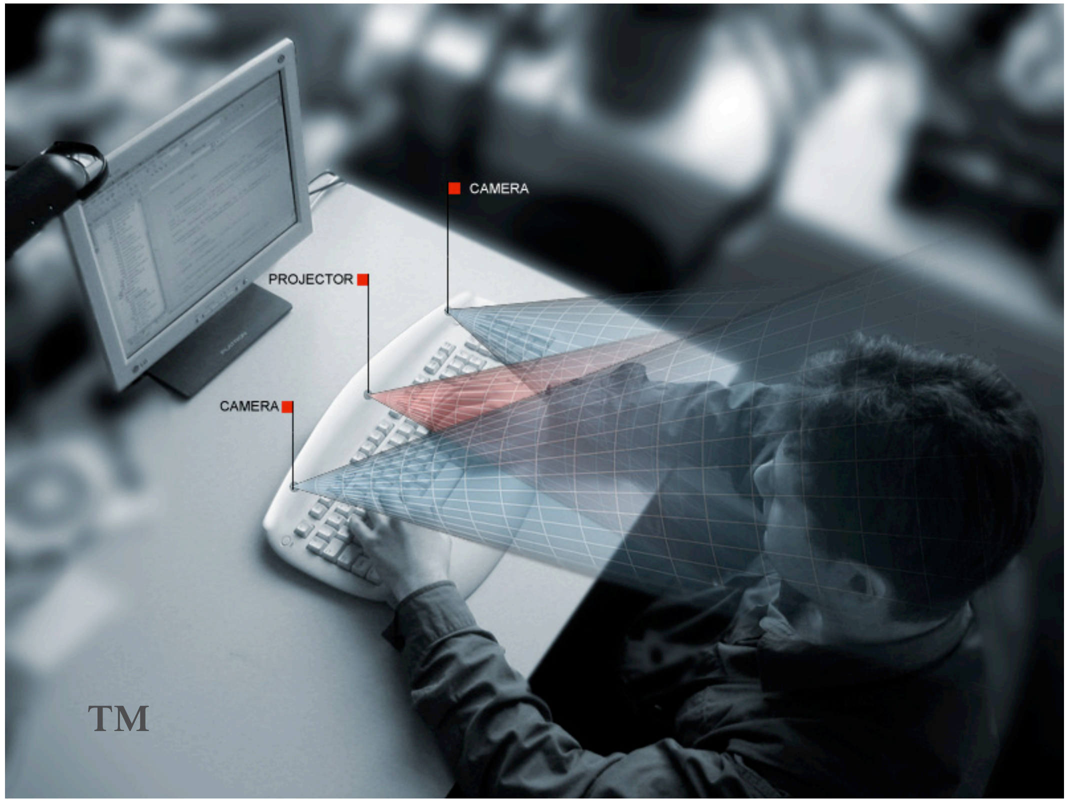
2D+3D Enrollment Booth.

NPO-Inform

powered by A4Vision 3D Face technology

A4Vision
Applications for Vision

Applications: logical access



Logical Access camera powered by A4Vision 3D Face technology

A4Vision
Applications for Vision

3rd party testing of A4 3D face technology

1. E-passports:
   1. Russia – Kaliningrad, 300 thousand people to receive a bio passport in 2006-2007 with biometrics. Operational pilot. Large-scale technology testing carried out in parallel (6-10 thousand people (3D & 2D) x 15 movies in a DB
   2. Singapore Immigration – over 1,000 participants, ~4,000 verifications per day on a device. Large scale operational testing
   3. Others non-public
2. Airports
   1. UK – operational testing. Separation of domestic/international passengers on boarding
   2. USA, France – access control in airport restricted areas
3. Commercial – banks, business-centers, casinos operational trials

A4Vision
Applications for Vision

3D Face Recognition Basics

<u>Source of biometrics:</u>

The shape of a human face regarded as a three-dimensional object

<u>Sensor:</u>

3D scanner (structured light, stereo, TOF, etc.)

<u>Capture procedure:</u>

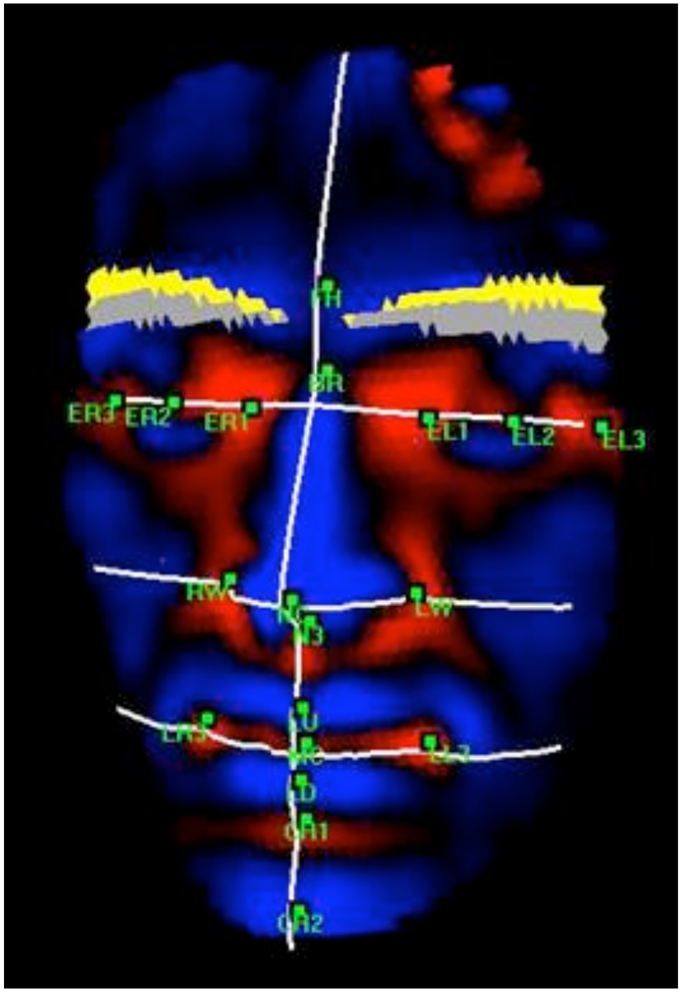
- contact less
- robust to ambient lightning conditions
- little cooperativeness required (positioning, moving, facial expressions)
- has to be fast, preferably real-time

<u>Biometric Sample:</u>

Cloud of points, meshed surface or range map representing the shape of a human face

A4Vision
Applications for Vision

3D Face sample



<u>Remark:</u>

Currently in 3D face recognition there is no standard set of extracted features like finger minutiae in fingerprint. Some matching algorithms may be using anthropometric landmarks, others – the general shape. Hence herein the quality characteristics of a 3D face sample are regarded as quality parameters of the corresponding surface in 3D.

This strategy is also followed in standards development in INCITS M1 and ISO/SC37. Anthropometric landmarks are included optionally.

A4Vision
Applications for Vision

3D Face signal processing pipeline

Info Source (intrinsic bio data)

Natural variations:

(Mimics, micro-movements, aging)

Human-device interaction (positioning)

Scanning process

(exp time, res, mult scan) – Noise is not uniform!!

Signal representation (cloud of points vs mesh vs depth map)

Signal analysis and processing (pose detection and feature extraction)

Feedback and matcher_dependent_quality check

Match/enroll

3D Face Sample Acquisition

Source

Scanner

Sample

Capture

Digitization

Each component has its impact on the sample quality.

A4Vision
Applications for Vision

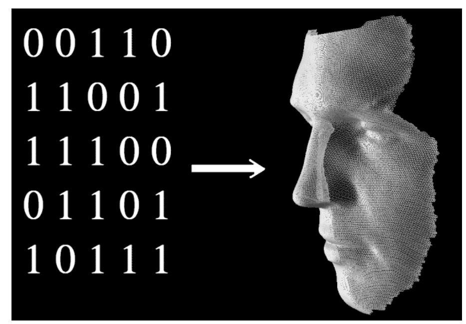
3D Face Sample Quality Factors

1. Source factors

2. Environment factors

3. Scanner factors

4. Digitization factors



A4Vision
Applications for Vision

3D Face biometrics source

The face is mostly soft tissue. There are natural face micro-deformations: talking, smiling, other mimics and grimaces, aging, seasonal changes, loss of fat.

3D biometric basement is provided by forensics.

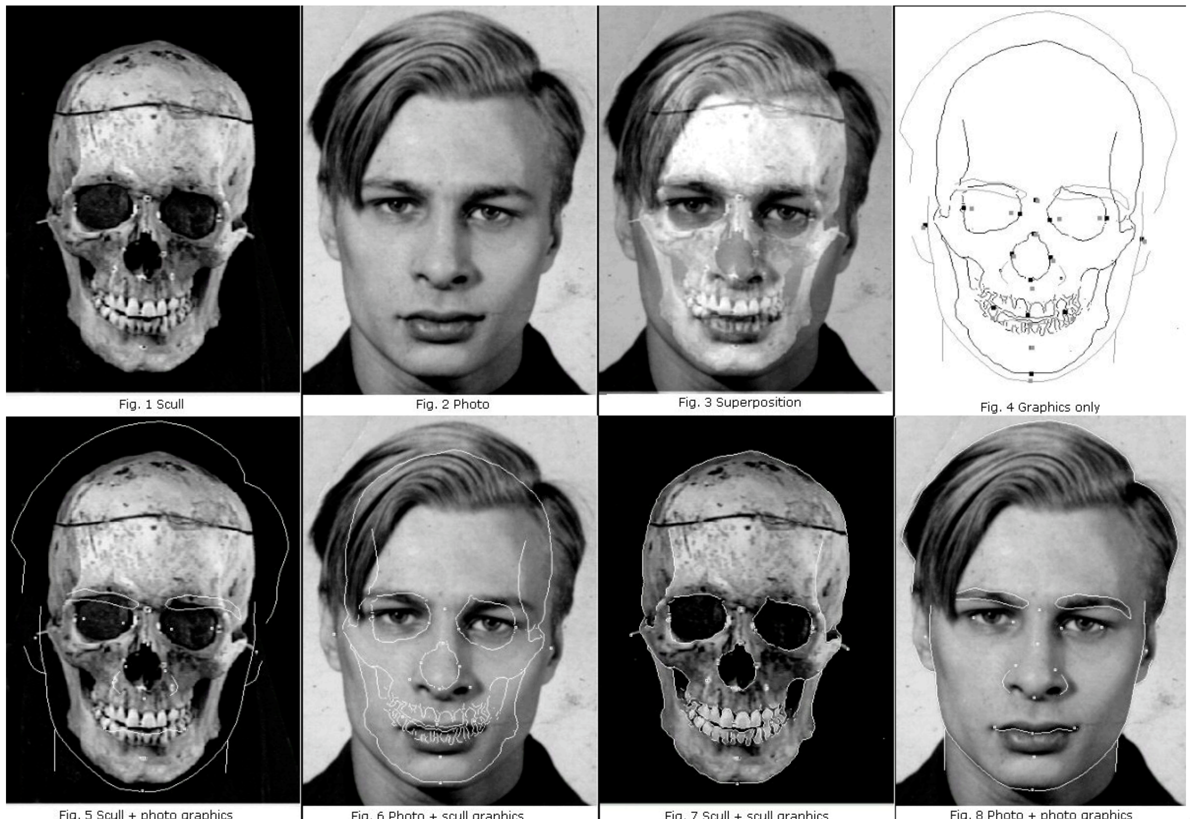
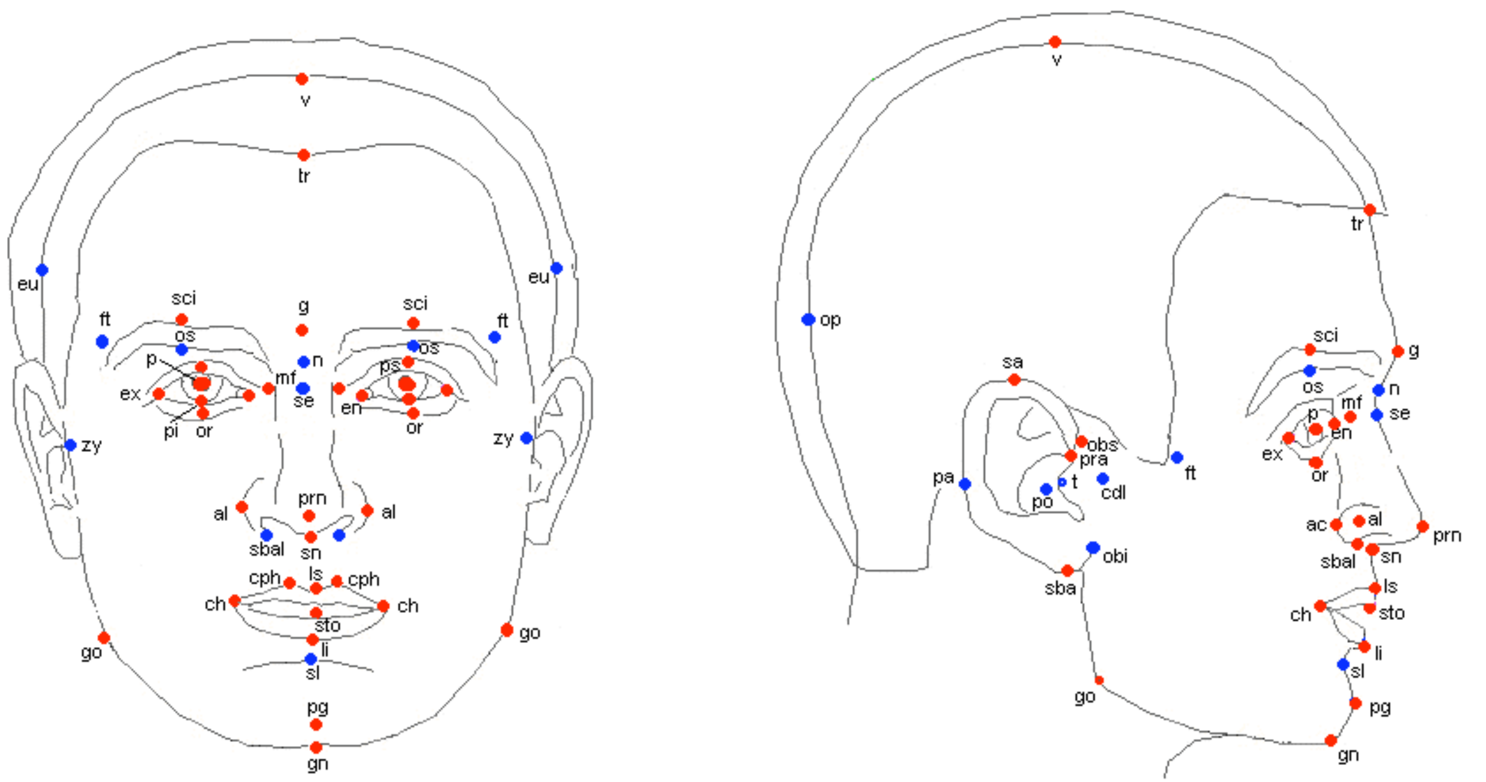


Fig. 1 Scull
Fig. 2 Photo
Fig. 3 Superposition
Fig. 4 Graphics only
Fig. 5 Scull + photo graphics
Fig. 6 Photo + scull graphics
Fig. 7 Scull + scull graphics
Fig. 8 Photo + photo graphics

A4Vision
Applications for Vision

Anthropometric landmarks

Anthropometric landmarks are defined by the geometry of the scull and remain unchanged. Deformed regions can be filtered and claimed invalid for a sample.



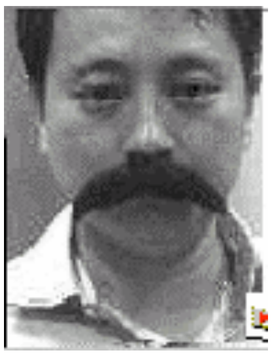
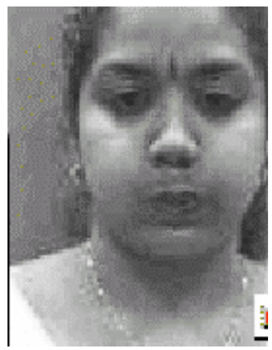
Anthropometric landmarks included in INCITS and ISO standard projects

A4Vision Applications for Vision

Examples: successful and failed verification samples in Singapore e-passport test

Successful:

Landmarks were found on valid regions

Failed:

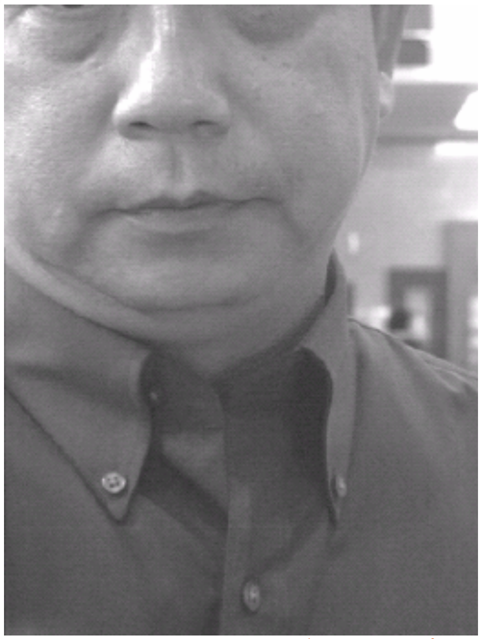
Too many invalid regions

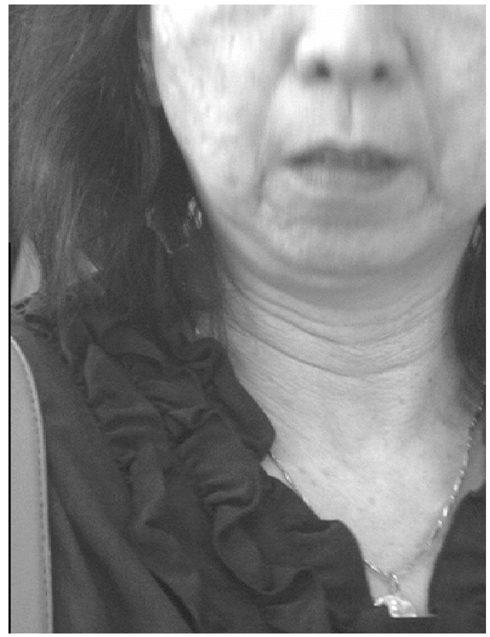


A4Vision
Applications for Vision

Human-device interaction: positioning

Examples of bad positioning from Singapore testing.



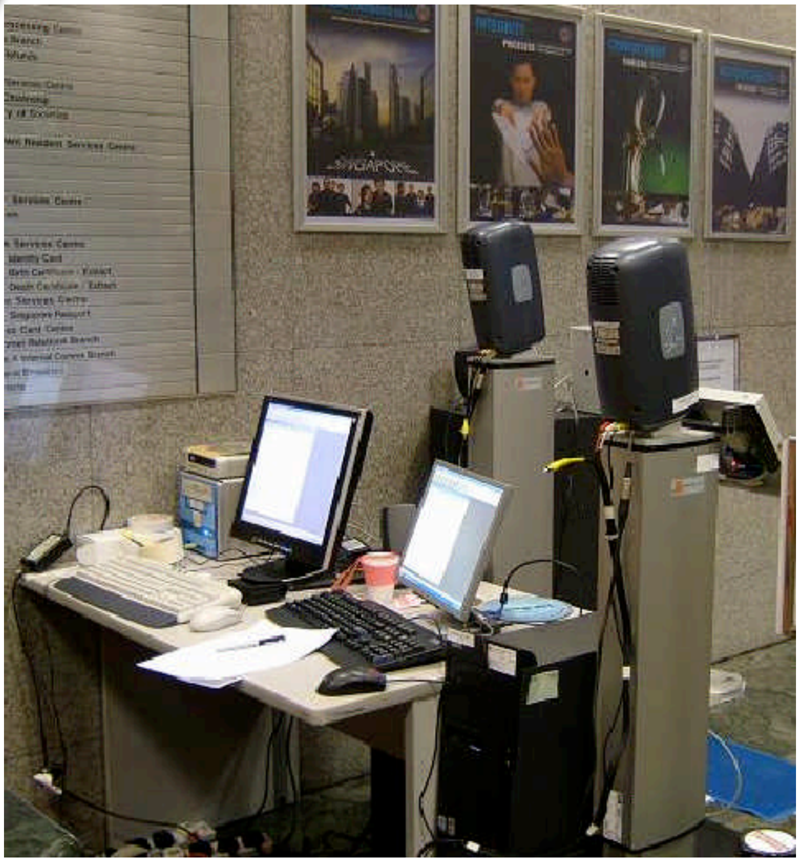


The testing showed that:

1. Improvements in usability, user interaction interface and ergonomics will reduce FRR greatly
2. Habituation reduced FRR twice within 3 weeks
3. People were not motivated to get a feedback by any door/gate and showed little co-operation effort

A4Vision
Applications for Vision

Enrollment/verification points in Singapore Immigration Authority



Users were not motivated to be recognized

A4Vision
Applications for Vision

Environment factors

- 3D face sample quality is robust to environmental factors and specifically to ambient light conditions

For 2D face the ambient lightning is an <u>indispensable component of the sample</u> itself. Hence it should be standardizes to guarantee a high-quality sample[1].

On the contrary, for 3D the light condition can only impact the scanning process; only illumination limits need to be specified to make the scanning possible.

[1] illustration extracted from ISO/IEC 19794-5

Scanner factors

- 3D scanner resolution, precision, signal-noise ratio and capture time set the upper limit for the sample quality

<u>Resolution</u>

Comparatively low resolution is sufficient for 3D face recognition. A minimum of 60 (120 preferred) pixels intra eye distance is required for 2D recognition (ref: ISO/IEC 19794-5). For 3D 30-40 dots intra eye distance proved to be a sufficient resolution.

<u>Precision</u>

A scanner mean error of ~0.5 mm provides biometric separation ability of FAR=10^{-7} while operational FRR remains suitable for most applications.

Scanner factors (continued)

<u>Capture time</u>

If the capture time (exposure) is significant (>0.1 sec) the 3D face sample quality is affected:

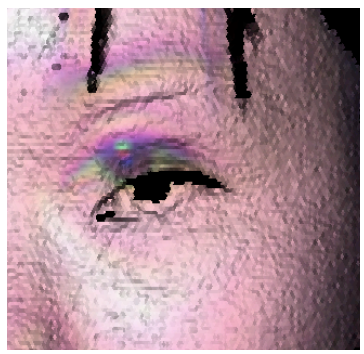
- the face cannot be fixed before the scanner like buildings, statues or factory made steel components – there are inevitable shifts in space
- the face continuously produces intrinsic micro-deformations

➢ High-quality sample requires short capture time

<u>Noise model</u>

Noise is not uniform and depends on the scanning angle. Creating a good noise model remain a challenge.

Exposure time artifact example: capture time in FRGC DB



Texture was captured after the surface. The shift is caused by 2.5 sec 3D exposure time: Person had time to move.

Example of a 2D photo taken with 2.5 sec exposure – what results would 2D show with such sample quality.

A4Vision
Applications for Vision

Digitizing Factors

<u>Surface registration and super-resolution</u>

Many 3D acquisition systems use multiple scans separated in space or in time to produce a single sample of higher quality. This requires surface registration or super-resolution building respectively.

• *surface registration* allows to produce a wider scan by creating one sample from several local scans

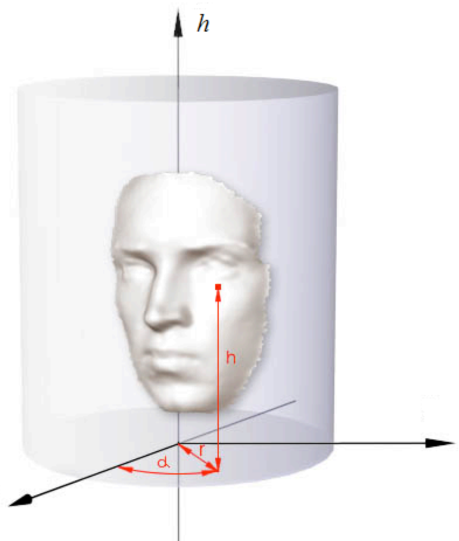
➢The precision of registration algorithms and/or the multi-camera systems calibration will affect the final sample quality.

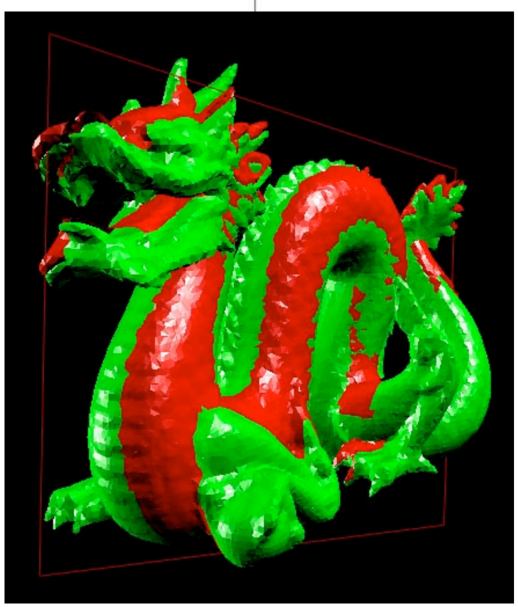
• *super-resolution* methods allow to increase the resolution of the sample by putting together several scans of the same area taken one after another. Precision is also improved by filtering outliers.

➢Time intervals between scans and their number will affect the final sample quality. The acquisition time shall be the time interval from the start of the first scan to the finish of the last.

A4Vision
Applications for Vision

Sample representation





- Cloud of points
- 3D mesh
- range map

Range Map is the main 3D face data representation method in INCITS and ISO data interoperability standards under development. Motivation:

- compact size ~ 5 KB (500 Kb for 3D mesh as VRML)
- regular structure, no additional processing needed
- Face has simple plane topology: range map imposes no crucial losses. Cylindrical map used for ear-to-ear scans

A4Vision
Applications for Vision

Thank you for attention!

COMPANY HEADQUARTERS - USA:

840 West California Ave. Suite 200
Sunnyvale, CA 94086
Tel: 408 446 1133
Fax: 408 746 3700
info@a4vision.com